Fixing the system strength frameworks

Discussion paper

CLEAN ENERGY COUNCIL

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Contents

Executive Summary

A strong and stable power system is necessary to support the transition to our renewable future.

The system strength frameworks underpin this process. System strength unlocks the capabilities of renewables, and is central to delivering cheap, reliable, zero carbon electricity supply to consumers.

The system strength frameworks are a series of technical and regulatory processes that enable the safe connection and operation of renewable generation and storage.

These frameworks are being implemented at the same time as the power system goes through major technical changes. This has exposed a number of weaknesses.

These weaknesses have made system strength too expensive. Generators face excessive system strength charges and uncertain processes, slowing down new connections and increasing the cost of new generation. Customers ultimately pay for these costs through higher energy and network charges.

The Clean Energy Council is focussed on collaborative and constructive working. This approach underpinned our highly successful Connection Reform Initiative program.

We stand ready to again work with all interested stakeholders, to develop new ways to improve the system strength frameworks.

Over the last six months we have engaged with our members to not only identify the key problems with the frameworks, but to begin the process of identifying workable solutions.

This report therefore sets out a pathway to make the system strength frameworks robust and fit for purpose.

It recognises the various workstreams already underway from the market bodies and highlights those areas where more work is needed. It proposes focussed reforms we consider will deliver net benefits for generators and consumers.

These reforms will follow various avenues, such as changes to the national electricity rules and AEMO guidelines. However, the clean energy industry also has a key role to play. Investors and developers recognise the need to work with AEMO, AER and AEMC to develop long term, sustainable solutions.

This report represents the first step in that collaborative process. The Clean Energy Council looks forward to working towards practical solutions to address these issues.

Summary of recommendations

1. System Strength Unit Pricing & Process for Node declaration

System strength Unit Pricing

Recommendation: the NER should be changed to impose limits to the variation that can occur between the lowest and highest System Strength Unit Price that can be determined across every node in a given region.

System Strength Node Declaration

Recommendations:

- The CEC supports AEMO in establishing additional system strength nodes, and to pre-emptively account for the effects of renewable support schemes such as the CIS. This would not require any NER or guidelines changes, however we encourage AEMO to declare these additional nodes as quickly as possible, through an update to the System Strength Report process.

- The NER system strength frameworks should be amended to allow for faster identification and development of additional system strength nodes, by formally requiring TNSPs to undertake assessments of potential hosting capacity, expected IBR volumes and likely new system strength node locations, and AEMO to consider this analysis in the System Strength Report.

2. Selection of a Suitable system strength node

Recommendation: A connecting generator should have the flexibility to select the most appropriate system strength node, based on the overall System Strength Charge and not purely on the lowest system strength locational factor (SSL).

3. System Strength Unit Price Transparency

Recommendation: Define ex-ante the specific assumptions and inputs to be used by TNSPs when determining System Strength Unit Prices. This should be achieved through greater specificity in the AER guidelines.

4. Resetting of System Strength Unit Prices

Recommendations:

- Amend the approach taken to allowed changes in the System Strength Unit Prices (SSUP) between system strength charging periods. It's recommended that a 'side constraint cap' is the preferrable approach -ie, the total SSUP can only ever be adjusted downwards between pricing periods.

- Introduce flexibility for System Strength Service Providers (SSSPs) to revise SSUPs downwards during a regulatory control period, where new information demonstrates that system strength obligations can be delivered at a lower cost than what was initially published.

5. System Strength Remediation Locations

Recommendation: Remove the restriction that prevents location of self-remediation in front of the connection point

6. Withstand SCR Assessment

Recommendation: AEMO, in consultation with industry, to reassess the specific tests applied to assess compliance with S5.2.5.15, to ensure their practicability, and to develop a methodology that sets out practical guidance as to how these tests should be conducted.

7. Grid Forming Inverters & System Strength

Recommendation: AEMO should provide further guidance and clarification regarding the treatment of grid forming inverters under the system strength frameworks, particularly as this relates to a grid forming inverters relative consumption, or provision, of system strength services

8. Transitionary Arrangements

Recommendation: AEMC to provide greater clarity on the transitionary arrangements for projects that were at the connection enquiry or connection application phase following commencement of the demand side rule.

9. Revoking an election in relation to paying the System Strength Charge

Recommendation: That generators have the ability to revoke a decision to pay the System Strength Charge and elect to self remediate, both during the period of connection application as well as during the main operational life of the generating asset. This should be pursued through the CRI review of the 5.3.9 frameworks.

10. Addressing System Strength on distribution networks

Recommendation: that the AEMC undertake a review of the practicality of allowing certain DNSPs to become SSSPs and more generally, how system strength services might be more effectively provided to generators looking to connect onto the distribution network

11. System strength requirements methodology: definitions of system strength

Recommendation: AEMO reassess the SSRM and SSIAG to

- ensure that system strength requirements and system strength costs to be borne by generators are only those related to control system stability / control system interactions and not power quality or other operational matters.

- ensure that volumes of fault level procured at nodes reflect actual and expected outcomes on the power system, rather than being based on a backwards looking view of power system needs.

Acronyms

The new System Strength Framework has introduced new concepts and new acronyms which are utilised throughout this paper. Where relevant, we have provided a plain English explanation for those not familiar with the terms in the table below.

Table 1. Definitions

Acronym	Definition	Explanation
AEMO	Australian Energy Market Operator	-
DNSP	Distribution Network Provider	-
IBR	Inverter Based Resource	Refers to an inverter or power electronics-based load or generator that consumes system strength.
NER	National Electricity Rules	-
OEM	Original Equipment Manufacturer	-
SSC	System Strength Charge	Refers to the overall System Strength annual charge that is payable by a connecting party. The SSC is the product of the System Strength Unit Price, System Strength Location Factor and System Strength Quantity. Refer Figure 2.
SSLF	System Strength Location Factor	This is a unitless quantity that represents the electrical distance from a SSN to the project. The higher the number, the larger the electrical distance. A value of 1.0 represents a project located at the SSN.
SSN	System Strength Node	Refers to an electrical location on the system strength service providers transmission network, where System Strength requirements and charges are calculated. Minimum fault level requirements and expected IBR connection forecasts are made at these nodes and new nodes can be added from time to time.
SSQ	System Strength Quantity	A metric used to quantify the amount of system strength 'consumed' by an IBR. The higher the number, the higher the System Strength Charge.
SSRS	System Strength Remediation Scheme	Refers to a solution provided by a connecting party to alleviate any system strength impacts. This typically occurs as an alternative to the connecting party paying the System Strength Charge.
SSSP	System Strength Service Provider	The network service provider responsible for procuring and delivering System Strength Services. This is typically the primary TNSP in the relevant region.
SSUP	System Strength Unit Price	A unit price in $ per MVA for delivery of System Strength Services as published by the SSSP. The SSUP is a key factor in determining the overall System Strength Charge.
TNSP	Transmission Network Provider	-

Background

What is System Strength? And what does it do?

System strength is a complex set of power system characteristics. Broadly speaking, a strong system is one that has a stable voltage and frequency. This enables renewable generation, like wind and solar, to stay connected during normal operation and following disturbances to the power system.

System strength can be thought of as a service that is both 'supplied' and 'demanded' on the power system.

System strength has been traditionally supplied by synchronous generation, like coal and gas. As these generators retire or are operated less frequently, we have seen a decline in system strength. However, hydroelectric generators and other forms of long duration storage, as well as specialised equipment like grid forming inverters and synchronous condensers, can all supply system strength.

On the demand side, certain types of inverter based resource (IBR) generation require a given amount of system strength to operate properly. Known as 'grid following' IBRs, these are usually wind and solar PV generators. In a sense, these generators can be said to 'consume' a volume of system strength when they connect and operate on the power system.

The combination of these two trends – a reduction in system strength supply as synchronous generators retire, plus an increase in demand for system strength as new IBR generators connect – has resulted in an urgent need to find new sources of system strength.

How is System Strength defined?

Before exploring issues with regulatory frameworks, we need to develop a basic understanding of the physics of system strength, and what it does on the power system. The text below provides a laypersons overview, with more detail provided in boxes.

The term 'System strength' was introduced several years ago, as a way of explaining several complex and inter-related elements. While interpretations vary as to what is meant by system strength, a good place to begin is the definition set out in the National Electricity Rules (NER).

This definition describes system strength by reference to doing two main things on the power system, being the provision of:

Minimum three phase fault levels.

This refers to the amount of 'fault current', which can be described as the amount of current available in the system. Fault current is key to stabilising voltage if there's a major short circuit event – known as a fault – and ensuring that special protection equipment can operate properly when the fault occurs. Effective operation of this protection equipment is critical to stopping the effects of faults from spreading, which is key to preventing major blackouts.

Stable Voltage Waveform.

This refers to managing some very complex new power system conditions, which are variously described as 'convertor driven instability', or 'control interactions'. Without getting lost in the engineering, this refers to specific interactions that can occur when there are lots of IBR connected to a weak part of the system, where the control software of each IBR interacts with that of its neighbours. Put simply, these interactions mean that small instabilities can rapidly grow in size – a feedback loop similar in form to a microphone held too close to an amplifier.

In more detail:

Minimum three phase fault levels

This refers to the minimum fault requirements to ensure devices such as protection system and voltage control equipment function correctly. Section 4 of AEMO's System Strength Requirement Methodology (SSRM) lists a seven-step process for determining Minimum Fault Level requirements which includes consideration of:

- existing requirements,
- protection systems,
- voltage control equipment needs,
- power system stability,
- planned outages and
- adjustments for operational needs,

Stable Voltage Waveform

The Stable Voltage Waveform definition is captured within the SSRM (Section 5) and refers to four key criteria to be addressed as part of any assessment:

- Voltage magnitude
- Change in voltage phase angle
- Voltage waveform distortion
- Voltage oscillations

Other definitions of System Strength

The term System Strength has traditionally been utilised however as a catch all term to identify weak or strong power systems.

"The AC system is considered as 'weak' from two aspects: (a) ac system impedance may be high, (b) AC system mechanical inertia may be low" - Power System Stability and Control, Prabha Kundur.[1]

Although there are various descriptions of the symptoms of low system strength on IBRs, the intent is to address issues associated with Resonant Instability and Converter Driven Stability associated with IBRs as captured in the recently revised Definition and Classification of Power System Stability.

For the purposes of this paper, we focus on the first two definitions described in this box, while noting that the conflation of these specific issues with others, such as power system quality and inertia, has created some confusion amongst policy makers and may be creating additional costs for consumers.

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[1] *"Definition and Classification of Power System Stability – Revisited & Extended",* in IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 36, NO. 4, JULY 2021, 2021.

System strength in the transition – what regulatory measures have been implemented so far to fix the issue?

The growing need to address system strength issues was recognised by policy makers a number of years ago.

There have been two key rule changes to deliver sufficient volumes of system strength. Below we provide a short summary of those changes. These regulatory reforms underpin the series of issues and proposed reforms described later in the paper.

Managing power system fault levels rule change[2]

The Australian Energy Market Commission (AEMC) initially sought to manage this issue through the *Managing Power System Fault Levels* rule change, which was released on 19 September 2017.

This rule created an obligation for transmission network service providers to provide a minimum level of synchronous fault current.

It also required generators to demonstrate through power systems studies that they did not have an adverse system strength impact on the power system or other proponents – the so called 'do no harm' provisions – and to undertake remediation actions to address any impact identified.

Under this initial framework, if an adverse impact was identified, a generator would need to provide a remediation scheme, such as building a synchronous condenser.

However, it also created significant additional complexity in terms of modelling requirements, as well as imposing additional costs on generators – such as installing the above mentioned synchronous condenser.

It also lacked the ability to coordinate delivery of system strength services and therefore missed out on harnessing potential economies of scale and scope. It also provided few incentives for connecting parties to target 'strong' parts of the network.

Efficient management of system strength rule change[3]

Recognizing the material shortfalls associated with the first rule, the AEMC released a second rule change on 21 October 2021. The *Efficient Management of System Strength Rule* was designed to proactively deliver the needed volumes of system strength.

The AEMC's second attempt sought to address these issues through the following measures:

- *New system strength charges*. The new rules introduced a framework of system strength charges, which were intended to send efficient price signals to connecting generators. Issues with these frameworks are at the core of why system strength is currently costing too much.
- *Proactive provision of system strength to support IBR*. The new rule introduced the concept of the 'efficient' level of system strength. Networks would now be required to proactively provide this amount of system strength, with a view to being able to support the stable operation of forecast volumes of connecting IBR generation. The costs of this network supplied system strength would be recovered through the system strength charges, as well as customer charges.
- *Harnessing economies of scale and scope for system strength supply:* Under the old rule, the 'do no harm' provisions resulted in many generators delivering their own, smaller system strength solutions. It was considered more efficient for network businesses to build or contract a smaller number of larger assets to deliver system strength, reducing costs by harnessing economies of scale and scope.
- *Defining volumes of system strength demanded by connecting generators*. The rule also sought to provide greater clarity around the volumes of system strength that connecting parties would consume, by setting clear technical standards for connecting parties.

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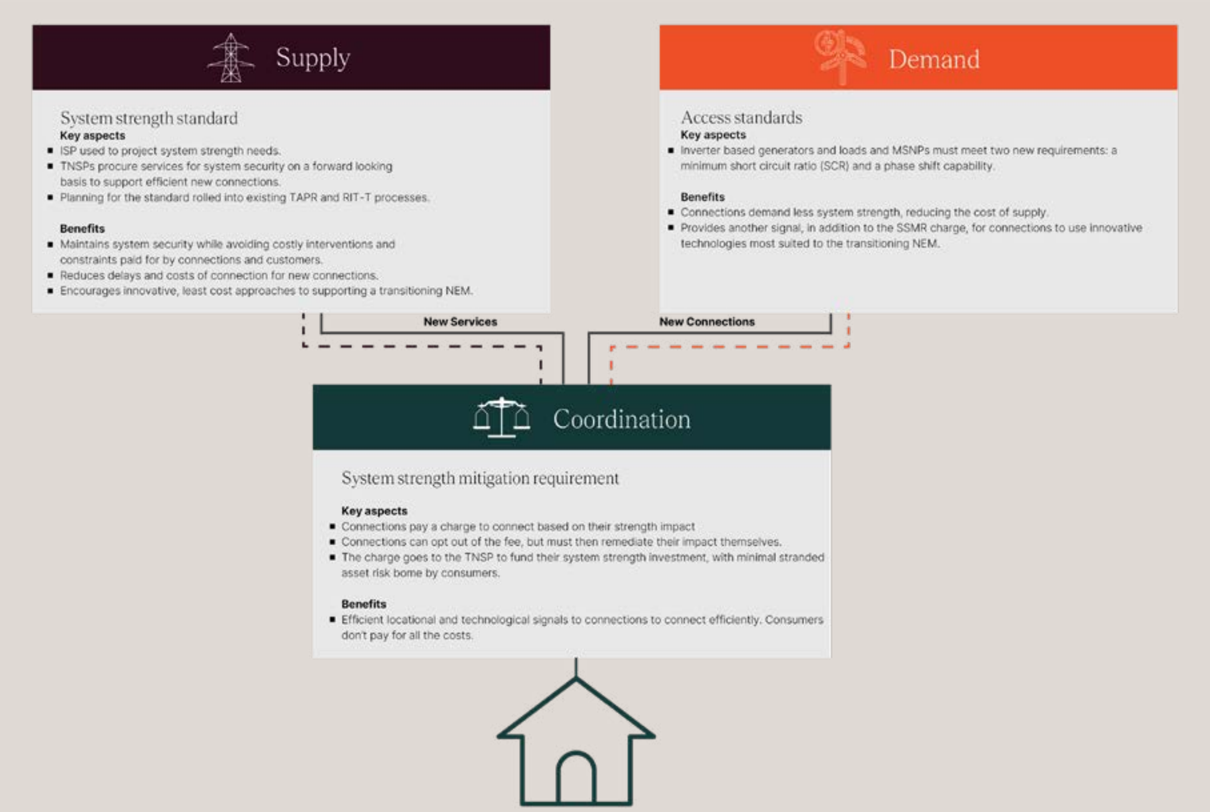
[2] Australian Energy Market Commission, Managing power system fault levels, Available: https://aemc.gov.au/rule-changes/managing-power-system-fault-levels

[3] Australian Energy Market Commission, Efficient management of system strength on the power system, Available: https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system.

In more detail:

How do the systems strength frameworks work?

The AEMC also described the system strength frameworks by reference to its three core components – the supply side, demand side and coordination components. The below diagram describes these components of the system strength frameworks.



Supply

System strength standard

Key aspects

- ISP used to project system strength needs.
- TNSPs procure services for system security on a forward looking basis to support efficient new connections.
- Planning for the standard rolled into existing TAPR and RIT-T processes.

Benefits

- Maintains system security while avoiding costly interventions and constraints paid for by connections and customers.
- Reduces delays and costs of connection for new connections.
- Encourages innovative, least cost approaches to supporting a transitioning NEM.

Demand

Access standards

Key aspects

- Inverter based generators and loads and MSNPs must meet two new requirements: a minimum short circuit ratio (SCR) and a phase shift capability.

Benefits

- Connections demand less system strength, reducing the cost of supply.
- Provides another signal, in addition to the SSMR charge, for connections to use innovative technologies most suited to the transitioning NEM.

Coordination

System strength mitigation requirement

Key aspects

- Connections pay a charge to connect based on their strength impact
- Connections can opt out of the fee, but must then remediate their impact themselves.
- The charge goes to the TNSP to fund their system strength investment, with minimal stranded asset risk borne by consumers.

Benefits

- Efficient locational and technological signals to connections to connect efficiently. Consumers don't pay for all the costs.

Figure 1 System Strength Supply and Demand Side Requirements (Source: AEMC)

Supply Side requirements – rule commenced 1 December 2022

A new obligation on transmission networks to proactively provide the right amount of system strength in a planning timeframe, to support the connection of expected volumes of inverter-based resources (IBR), as forecast by AEMO through the ISP.

Demand side requirements – rule commenced 15 March 2023

A new access standard for those parties that 'demand' system strength – large controllable loads like hydrogen electrolysers, and generators such as batteries, utility-scale solar and wind farms – to make sure they use system strength efficiently, reducing demand for it and minimising costs associated with supply.

System strength charge (coordination measures)

The system strength charge itself is made up of three components:

- The system strength unit price (SSP, or SSUP): Calculated by each TNSP by reference to forecasts of the technology solution to meet the system strength need. The SSP is recalculated every five years.

- The system strength locational factor (SSL): Calculated by AEMO, reflecting the electrical 'distance' between the source of system strength and the generator. The more distant the generator from the system strength, the higher the locational factor
- The system strength quantity (SSQ): Calculated by AEMO, which defines how much system strength a generator 'uses' when it connects. Certain types of generators require more system strength than others, and therefore have higher SSQs.

Figure 2 System Strength Charge Calculation (Source: AEMC)

Different parties face various responsibilities under the system strength frameworks:

- **AEMO** plans for required levels of system strength. AEMO is responsible for defining system strength 'nodes' – being specific locations on the power system – as well as the system strength volumes needed to support the volumes of IBR expected to connect at each node. AEMO also defines many technical elements of system strength through the System Strength Requirement Methodology (SSRM) and System Strength Impact Assessment Guidelines (SSIAG).
- **Transmission network service providers (TNSPs)**, when they are defined as system strength service providers (SSSPs), build assets or procure services to provide system strength, up to the level required by AEMO. This could include building assets such as synchronous condensers or transmission lines. Equally, TNSPs may contract with third parties, such as synchronous generators, to provide system strength services as a non-network solution.
- **Connecting generators (and some loads):**
    - pay a charge to use the system strength provided by the TNSP – the system strength charge; OR
    - build equipment or contract services from other parties to meet their own requirements for system strength. This is commonly known as 'self-remediation'.
    - connecting generators must also meet specific technical requirements related to the base amount of system strength they can consume on the grid.
- **Customers** pay for the balance, being the cost of any system strength that's procured by the TNSP but isn't used by connecting generators and loads.

The calculation of the system strength charge (SSC) is quite complex and contains several components, reflecting the quantity of system strength demanded by an IBR generator, the location of the IBR generator, and cost of delivering the system strength at the closest 'node' in the power system.

Importantly, generators must be able to effectively and freely choose between paying the charge, or undertaking their own actions to supply their own system strength. For this reason, it is important that the approach to calculating the charge delivers outcomes that are comparable to the costs of generators supplying their own system strength.

What's the problem?

These system strength regulatory frameworks were introduced at a time when the power system is going through a major physical reset. They encompass and try to reconcile multiple technical, regulatory and commercial drivers, some of which are changing rapidly.

It has also been necessary to introduce the new regulatory frameworks slowly, to allow the many parties involved in the process to do their work. However, this has not always aligned well with the speed of the technological evolution and commercial development of the power system itself.

A number of issues have therefore arisen, as these regulatory frameworks have been implemented. These issues boil down to one thing – the cost of supplying system strength is too high. This will ultimately flow through to consumers as higher energy bills, and potentially impacts on energy security and reliability. It's therefore critical that industry and government work together to address these critical issues.

The market bodies – the AEMC, AEMO and AER – have begun working to try and address these issues. The Clean Energy Council is committed to supporting this work of reforming and improving the system strength frameworks. The first step in this process is a clear identification of those issues that are having the greatest impact on generators.

The Clean Energy Council engaged with our members to clearly identify these issues, and to start the process of developing solutions. The rest of this report provides a snapshot of the key issues and maps out potential channels to address them. We look forward to working with industry and government in 2024, to find a way to fix these critically important frameworks.

Challenges and potential ways forward

Following commencement of the demand side component of the *Efficient Management of System Strength* rule on 15 March 2023, numerous concerns were raised across industry and by CEC members regarding the application of the rule and its impact on the delivery of projects.

Due to an absence of consolidation of the issues and their severity, the CEC surveyed members to better understand the key issues.

Consequently, 12 key issues emerged following feedback from a diverse range of stakeholders including project developers, network service providers, OEMs and consultants.

The key issues are summarised in Figure 3 below.

We also identified a set of indicative solutions to these issues, which are intended to provide guidance and suggestions to the market bodies as they proceed to reform the frameworks. In many instances, its acknowledged that solutions are already underway. In others , we have highlighted a range of solutions that could be considered, including whether these will include regulatory, guideline or simply procedural changes.

In some cases, the recommendations made in regards to one issue area, may well help resolve another issue area. Where possible, we have mapped these interactions, but consider that the market bodies are well placed to assess this interplay and identify the optimal combination of solutions.

The CEC will look to work with market bodies, industry and government agencies to explore next steps. This may include the drafting of rule change requests.

Quantity calculation

Developing System Strength Quantity (SSQ) values that are a fair reflection of actual system impacts of connecting generation.

Unit pricing

Delivering certainty in regards to System Strength Unit Prices (SSUP) in a region.

Transitionals

Clarity and certainty on transitionary arrangements of the new rule.

Technical assessment

Ensuring that tests to manage short circuit ratio (SCR) withstand are workable.

Grid forming

Certainty on the treatment of grid forming inverters as this relates to payment of System Strength Charges and self remediation.

Remediation locations

Allowing for the most efficient self remediation options to be determined, including those which exit infront of the point of connection
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Price reset

Reducing uncertainty regarding System Strength Unit Pricing (SSUP) and how these prices will change between and within five year pricing periods.

Definitions

Revising and clarifying the definitions of System Strength to ensure that costs are efficient.

Node selection

Allowing developers to select for the most efficient system strength node, when developing a project.

Switch to self remediation

Enabling generators to change from paying the system strength charge, to managing their own system strength impact.

Price transparency

Improving transparency around the process for setting System Strength Unit Prices (SSUP) by NSPs.

Figure 3 System Strength Priority Issues

1. System Strength Quantity Calculation

This issue has largely been addressed through a rule change recently completed by the AEMC. We consider resolution of this issue represents a significant step towards rectifying the issues with the system strength framework.

A summary is provided here for interested parties. Further unresolved issues are described in subsequent sections.

Connecting generators can choose to use the system strength service provided by the TNSP, or undertake self-remediation.

If generators use the system strength service, they pay the System Strength Charge. This consists of three components – the locational factor (SSL), unit price (SSP) and the system strength quantity (SSQ).

The SSQ component refers to the *quantity* of System Strength 'consumed' by a connecting generator. Some forms of technology, such as grid following inverters, consume or require a given volume of System Strength, in order to operate in a stable manner. Other types of technology, such as grid forming inverters or synchronous generation, require far less system strength, or may actively 'produce' it – these technologies have a much smaller, or even zero, SSQ.

Generally speaking, the more System Strength that is consumed, the higher the SSQ value will be. This translates into a higher final System Strength Charge.

The calculation of the SSQ is defined in the NER (NER 6A.23.5(j)). A key problem with this definition is that it can overstate the system strength consumed by a connecting generator, and hence the total applicable System Strength Charge. This occurs because the current definition of the SSQ doesn't account for the base level of System Strength inherent in the system.

The current approach to the calculation of the SSQ can therefore artificially inflate the final System Strength Charge.

This means the System Strength Charge can appear more expensive to a generator, as opposed to undertaking self-remediation. Given that connecting generators can choose between paying the System Strength Charge or self-remediating, an artificially high System Strength Charge will tend to incentivise generators to self-remediate.

This outcome would run contrary to the core purpose of the original system strength frameworks, which was to reduce total system strength costs by allowing SSSPs – usually the local transmission network company – to harness economies of scale and scope, and therefore lower the total costs of supplying system strength.

If generators face an artificial incentive to self-remediate, these scale and scope economies may not be captured. It also creates a material risk that system strength assets built by TNSPs will be underutilised by connecting generators, pushing costs onto consumers (remembering that any system strength costs incurred by TNSPs are ultimately recovered through the transmission charges faced by customers).

AEMO has actively managed this issue by introducing a specific 'stability coefficient' in its System Strength Impact Assessment Guideline (SSIAG). This stability coefficient has the effect of addressing the apparent imbalance between the System Strength Charge and self-remediation, by recognising the inherent System Strength that is in the system and the improved capability of modern IBR to operate at very low levels of system strength.

The AEMC has now made a final determination in the Calculation of system strength quantity rule change.[4]

The CEC considers this rule change represents a sensible outcome, and largely addresses the issue identified.

System Strength Quantity Calculation – Addressing the Issue

- The core issue is that the original approach to SSQ calculation was inaccurate and made the System Strength Charge appear more expensive than self-remediation. This defeats the core purpose of the System Strength Framework.
- This was addressed by recognising the inherent levels of system strength in the system and allowing for the improved capability of IBRs to operate at low levels of system strength.
- AEMO has proposed to do this by moving the definition of SSQ to a guideline, outside of the NER - the SSIAG as proposed by AEMO in its rule change request.
- The CEC supports AEMO's rule change to modify the SSQ calculation in the NER, subject to further development and application of a suitable formula that accurately captures any improved capability of IBRs – particularly grid forming capabilities.

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[4] Australian Energy Market Commission, *Calculation of system strength quantity*, 19 September 2023. Available: https://www.aemc.gov.au/rule-changes/calculation-system-strength-quantity.

2. System Strength Unit Prices and system strength node declaration

This section covers two interrelated issues:

- The approach to calculation of system strength unit prices across nodes in a region; and
- The process for system strength node declaration

Calculation of System Strength Unit Price across nodes in a region

The System Strength Unit Price (SSP or SSUP) is one of three components that make up the overall System Strength Charge.

The System Strength Unit price is based on the forecast cost for the relevant SSSP / TNSP to provide a system strength service. It may include forecast costs of building an asset like a synchronous condenser, or the cost of contracting with a synchronous generator to provide system strength.

System Strength Unit Prices are published by NSPs, in accordance with a methodology that the TNSPs develop, following AER guidelines. These SSPs must be developed on the basis of forecast long run average costs over a ten year period.

Some very high SSUPs have recently been determined at some nodes, in the inaugural round of price determinations. This resulted in high overall System Strength Charges that generators will be required to pay. Furthermore, System Strength Unit Prices can also vary significantly within a region, with markedly different prices at different system strength nodes.

For example, marked differences occurred between several of the SSUPs calculated in Queensland. The differences in SSUP at the Greenbank node ($15,681 / MVA) and the Western Downs node ($2,678 / MVA) varied by a factor of over 585%. This is despite there being no IBR forecast to connect to Greenbank, yet Greenbank remains a System Strength Node.

We note that Powerlink has devoted significant resource to addressing this issue, and has lodged a rule change with the AEMC requesting a revision of the prices calculated for the various QLD nodes. This is likely to address the specific issue identified in QLD. However, we consider that structural issues remain, and warrant permanent solutions.

SSUPs are an important part of the System Strength Charge, however they should be considered along with the other elements of the System Strength Charge – including the locational factor (SSL) and quantity (SSQ) - in consideration of the overall cost to deliver system strength services.

The implication of overly high SSUPs is that System Strength Charges will in turn be determined that are unattractive, incentivising generators to undertake self-remediation instead. This is exacerbated by the issues already identified with the SSQ described above, and by the uncertainty associated with the five yearly SSUP reset, as described below.

If generators elect to self remediate rather than pay the System Strength Charge, system strength services provided by TNSPs may be underutilised, and TNSPs may be forced to recover a larger share of the total cost of providing system strength services from consumers.

It is therefore clearly in all parties interests to set the SSUP at levels consistent with full utilisation of the available service.

As with the approach to the SSQ, to encourage coordinated and centralised System Strength solutions, the principle should be that SSUPs should not be materially higher than what an individual connecting party would pay if they decided to self remediate.

We consider there are several approaches that could be taken to deliver this outcome.

Firstly, limitations could be placed on the difference that can exist between System Strength Unit Prices that are calculated at each node in a region. Currently, significant variances can occur in System Strength Unit Price across nodes in a region, which may create an incentive to locate closer to a particular node, even if this does not align with other factors such as planning requirements, land availability, community acceptance or resource availability. More generally, this situation can result in excessively high System Strength Unit Prices, which in turn create strong disincentives to utilise the system strength service at the relevant node.

Conflicts may also exist here with the system strength locational factor, which is intended as the primary driver of locational decisions as regards system strength.

Limiting the extent of the allowed variation in SSUP between nodes in a region would help to simplify matters for generators while allowing for the primary locational signalling element of the System Strength Charge to operate effectively. It would also prevent excessively high SSUPs being determined at any given node.

Secondly, another way to address this issue would be to require greater transparency and certainty around how TNSPs approach the calculation of the System Strength Unit Prices – this is explored in more detail in the next section.

Determination of system strength nodes

The effects of high and unpredictable System Strength Unit Prices can be exacerbated by the approach to determining System Strength nodes.

A System Strength node is a nominated point on the system where AEMO determines the necessary volumes of system strength service that the relevant TNSP must provide.

The number and location of system strength nodes may not be keeping pace with the speed of new investment in IBR , especially as the expanded Capacity Investment Scheme (CIS) begins to take effect in coming years.

Currently, AEMO is responsible for declaring system strength nodes, on the basis of meeting various requirements set out in the NER, as well as the exercise of its own policy judgement. This includes requirements to consider the projections of the ISP and to engage with TNSPs through joint planning processes. AEMO also considers jurisdictional and Commonwealth policy interventions in this process.

The NER already provide AEMO with significant leeway to determine both node locations and numbers, as well as the volumes of IBR forecast to connect near each of those nodes. This is set out in clauses 5.20C.1 and 5.20.6 of the NER.

AEMO then interprets these general requirements through its System Strength Requirements Methodology (SSRM), which in turn informs the annual System Strength Report, where the node locations and volumes are published.

The number and the location of system strength nodes have two key impacts on a new connecting IBR generator.

Generators will be incentivised to locate closer to nodes that have lower System Strength Unit Prices. This is also affected by the effect of the system strength locational factor (SSL), which incentivises generators to locate as close as possible to that node.

Generators therefore face strong investment signals to develop projects as close as possible to specific system strength nodes. However, there are practical limitations with this approach, in that there is often insufficient land and/or energy resource available to develop a project adjacent – or more formally, electrically close to - the optimal system strength node.

Furthermore, we consider it likely that the number of nodes declared will need to increase markedly in coming years, to reflect the number of new renewable projects that will need to be developed, especially given the recently announced expanded Capacity Investment Scheme. Furthermore, the locations of existing nodes are not always aligned with locations where projects are being developed. Consequently, these investment signals are lagging project development and discouraging or delaying new investment due to high SSUPs.

System Strength Unit Pricing & Process for Node declaration - Addressing the Issue

There are various options that could be pursued to address both the issues identified above.

System strength Unit Pricing

Recommendation: the NER should be changed to impose limits to the variation that can occur between the lowest and highest System Strength Unit Price that can be determined across every node in a given region.

One of the key issues is the variability of System Strength Unit Prices that can be determined across the power system.

Determination of the actual System Strength Unit Prices is guided by AER pricing methodology guidelines, which define how TNSPs set their SSUPs.

NER clause 6A.25.2(h) requires the AER to consider when developing its system strength pricing guidelines:

- "the desirability of providing efficient investment and system strength transmission service utilisation signals to actual and potential System Strength Transmission Service Users based on the long run cost of providing system strength transmission services at the relevant location"; *and*

- "the desirability of consistent pricing structures across the NEM"

For the reasons set out above, we consider there are material efficiency benefits associated with reducing variation in the System Strength Unit Prices determined across different nodes in a given region. This is consistent with providing efficient investment and locational signals, as it takes into account the many other drivers of renewable generation investment that feed into efficient locational decisions - not just those related to the LRMC of system strength service provision at a specific location.

We consider this approach could be enabled by amending the NER to require the AER guidelines to include a methodology that describes the maximum allowed variation in SSUP across all nodes in a region, and how this should be applied by TNSPs.

Alternatively, the NER could itself define the value of this maximum variation. While this would support efficient investment by providing increased certainty for investors, it would need to be balanced against maintaining some signal reflecting the LRMC of system strength at the relevant node.

The CEC acknowledges this approach could cause SSUPs at any given node to vary from the underlying long run cost of providing the service, and may therefore cause some cost cross subsidisation to occur between nodes. However, we consider any reduction in efficiency of locational signalling will be outweighed by the more efficient investment signals provided by stable and predictable unit pricing.

We also note that locational signalling is more appropriately provided by the system strength locational factor component of the System Strength Charge. On this basis, minimising the variation that can exist between SSUPs at different nodes will reduce any locational signals that might run contrary to those provided by the SSL, which is the formal mechanism designed for this purpose.

System Strength Node Declaration

Recommendation:

The CEC supports AEMO in establishing additional system strength nodes, and to pre-emptively account for the effects of renewable support schemes such as the CIS. This would not require any NER or guidelines

changes, however we encourage AEMO to declare these additional nodes as quickly as possible, through an update to the System Strength Report process.

We consider there are likely to be benefits in AEMO taking a more proactive approach to declaration of system strength nodes, particularly as major policy interventions like the CIS come into effect and markedly increase the volumes of new IBR generation that will need to be hosted on the power system.

AEMO already has significant leeway to do this. AEMO acknowledges that it may depart from the forecasts of the ISP "in cases where updated market modelling is available (for example from the ESOO), where a material market, policy or technology change has occurred".[5] We consider the CIS to be a significantly material policy change that may warrant AEMO taking a more proactive approach to node declaration.

AEMO published the 2023 System Strength Report in late 2023, but has not at this time declared any new nodes. However, it has identified several *proposed* system strength nodes. [6] This includes new nodes identified in NSW, SA and Queensland, reflecting likely new areas of renewable investment and retirements of synchronous units.

The CEC recommends AEMO declares these nodes as soon as it is practicable to do so, through the system strength report process. As identified, this requires no rule or guideline changes as it falls well within AEMO's remit. The CEC is strongly supportive of AEMO utilising its powers here to proactively declare new nodes, to support investment where it is most needed.

Recommendation:

The NER system strength frameworks should be amended to allow for faster identification and development of additional system strength nodes, by formally requiring TNSPs to undertake assessments of potential hosting capacity, expected IBR volumes and likely new system strength node locations, and AEMO to consider this analysis in the system strength report.

AEMO's work could be complemented by better processes to feed investment market information up into the high level AEMO planning processes.

Currently, AEMO's node declaration decisions and forecasts of hosted IBR volumes are based on their own assessments through the ISP, or other centralised planning processes, as well as their own interpretation of other policy drivers.

The frameworks also include requirements for AEMO to engage in joint planning processes with TNSPs when determining system strength nodes. However, these elements of the frameworks are relatively unclear and could be enhanced.

The CEC has been calling for reforms to improve and standardise TNSP hosting capacity forecasts for several years. We consider that obligations on TNSPs to more clearly forecast IBR volumes likely to connect, and therefore likely available hosting capacity on different parts of the network, would support more coordinated transmission and generation investment outcomes.

We therefore recommend a new framework be introduced to require TNSPs to undertake their own forecasts of expected IBR penetration and associated hosting capacity within their region, with a view to proactively identifying likely new system strength nodes. These forecasts could be published in the relevant TAPR. AEMO should then face explicit obligations to consider these forecasts and respond to them in each system strength report.

This approach would require additional changes to the NER, primarily around the planning provisions in Chapter 5.

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[5] AEMO, System Strength Requirements Methodology, December 2022, p.25.

[6] AEMO, 2022 System Strength Report, December 2023

3. Selection of a Suitable SSN

This section considers the benefits associated with allowing proponents greater flexibility to select the specific system strength node upon which their system strength charge is calculated.[7]

As described above, the overall System Strength Charge payable by a connecting party is dependent upon the applicable system strength node, as the node that is selected has a direct impact on:

- The applicable system strength locational factor (SSL)
- The applicable system strength unit price (SSUP)

Selection of a system strength node for the purposes of calculation of an SSL under the System Strength Impact Assessment Guideline (SSIAG) is based on utilising the electrically closest system strength node to the project.

However, this is problematic in that it does not consider overall system strength costs. Flexibility should be provided to select an alternative system strength node, where the total System Strength Charge could be lower if connecting to a different system strength node, despite a higher SSL.

As discussed above, the SSUP also varies between system strength nodes. This means there are cases where the overall System Strength Charges could be less, even though there is a higher SSL, if the System Strength Unit Prices are lower for an alternative node.

For example, a project connecting in Queensland may have very similar SSL values to three different System Strength Nodes (Gin Gin, Greenbank, Western Downs in this case) with minor differences in SSLF (e.g., 1.047, 1.044 and 1.045 respectively). As per the System Strength Impact Assessment Guideline, the applicable System Strength Node would be Greenbank (lowest Locational Factor, hence closest electrically).

However, the original System Strength Unit Price for Greenbank was $15,681/MVA/year, compared to $8,419/MVA/year for Gin Gin, and $2,678/MVA/year for Western Downs. [8]

As a result, the total charge calculated using Greenbank as the System Strength Node will be almost twice that of Gin Gin, and six times higher than Western Downs.

The inability to actively select a system strength node pertaining to the lowest overall cost would result in projects being exposed to unrealistic System Strength costs.

Selection of a Suitable system strength node – Addressing the Issue

Recommendation: A connecting generator should have the flexibility to select the most appropriate system strength node, based on the overall System Strength Charge and not purely on the lowest SSL.

Selecting a System Strength Node based on the lowest Locational Factor alone does not result in the lowest overall System Strength costs, and can result in generators being exposed to inefficient pricing outcomes. This may in turn drive inefficient investment decisions.

We consider that some flexibility should be provided, to allow connecting generators some leeway to nominate the specific system strength node they would like to use as the basis of their System Strength Charge. This will support more efficient investment decisions.

We consider this change is likely to be achievable through relatively minor changes to the SSIAG.

As noted above, we also acknowledge that the materiality of this issue is somewhat reduced if a cap to difference in SSP can be determined in region, although its noted that the SSL remains variable.

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[7] The CEC acknowledges that the materiality of this issue reduces if SSUP price variation across nodes is applied in each region, as discussed in section 3.2 above.

[8] The CEC acknowledges that Powerlink has indicated these values will be reduced, following the lodgement of its rule change request to the AEMC to reset its SSUPs.

4. Transparency in the process of setting system strength unit prices

The basis for setting System Strength Unit Prices varies across the NEM. CEC members have raised concerns around the lack of transparency on the process for setting System Strength Unit Prices by NSPs.

TNSPs develop their SSUPs in accordance with guidelines developed by the AER. However these guidelines are at a relatively high level, with TNSPs having to exercise a degree of discretion in terms of how these guidelines should be interpreted. This can include TNSPs having to make interpretations as to what costs should be included or excluded in SSUP calculation - for example, some NSPs have included operating costs and auxiliary load in their costs, while others do not.

We acknowledge that some TNSPs have provided some transparency around their interpretation of the guidelines. For example, TransGrid[9] has provided some information on their website, while other NSPs such as Powerlink have provided their reasoning through public online consultation processes.

However it appears that TNSPs continue to make different assumptions regarding what is and is not included in the determination of SSUPs.

We consider that a lack of clarity regarding the appropriate interpretation of these AER guidelines may have contributed to the significant variation in SSUPs as identified above.

We therefore consider there would be significant efficiency benefits associated with assisting TNSPs in developing a more standardised approach to the interpretation of the AER guidelines.

System Strength Unit Price Transparency - Addressing the Issue

Recommendation: Define ex-ante the specific assumptions and inputs to be used by TNSPs when determining System Strength Unit Prices. This should be achieved through greater specificity in the AER guidelines.

This could be enabled by providing a standardised approach to the following elements:

- Requiring TNSPs to state all cost assumptions when determining System Strength Unit Prices.
- Assumptions on technology solutions considered and sensitivity of costs to changes in technology.
- Clarity on other assumptions that would have a material impact on the SSUP such as O&M costs and losses.

We understand that TNSPs have actually sought to align approaches on these matters, prior to the most recent System Strength Unit Price determinations, but decided this may run contrary to competition laws.

It follows that a NER based requirement may be necessary, to make it clear that this ex-ante standardisation is a statutory obligation. The NER would also need to specify that these approaches should be published on a regular basis.

We also expect that the AER may need to work with the ACCC, perhaps to explore authorisations, to provide comfort to TNSPs that this standardisation is not contrary to Australian competition law requirements.

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[9] Transgrid, *2023-24 System Strength Unit Prices, Calculation methodology for Transgrid's 2023-24 System Strength Unit Prices, 2023*. Available: https://www.transgrid.com.au/media/etjhsguc/transgrid_2023-24_system-strength-unit-price-methodology_summary.pdf. [Accessed 8 November 2013].

5. Resetting of System Strength Unit Prices

Currently, System Strength Unit Prices are recalculated and reset every five years. There are two issues associated with this:

- **Investor risk perception that System Strength Unit Prices will increase between each five year period**, driving higher investment costs to manage this risk, or increasing incentives to select for self remediation instead of paying the System Strength Charge.
- **Inability to revise System Strength Unit Prices downwards during the 5 yearly period**, resulting in inefficient prices being locked in, even where new information becomes available that indicates SSUPs could be reduced.

Risk perception of increases in System Strength Unit Prices between each five year period

System Strength Unit Prices are determined on a 5-year period, with TNSPs required to recalculate these prices and apply them to run from the second year of their regulatory control period, through to the second year of the next control period.

This 5 yearly reset was intended to provide an accurate reflection of the costs of providing system strength in the SSUP. However, given there is little that a generator can do to respond to a change in the System Strength Unit Price once it is connected, it's entirely unclear how this more accurate reflection of underlying cost will flow through into more efficient investment or operational decisions. This is exacerbated by the issues noted below, related to the difficulty of shifting from paying the System Strength Charge to self-remediation, once this decision has been made.

The five yearly SSP reset is also inconsistent with the operational lifespan of most renewable generation. A five yearly reset of a significant project cost like system strength does not align well with a typical renewable generation asset operational lifespan of 20 to 30 years.

This misalignment creates a key uncertainty for investors in new generation. When the system strength frameworks were introduced, it was assumed that learning rates, technological developments and input cost reductions would naturally lead to a downward trend in SSUPs over time. It was believed this would address any uncertainty caused by the misalignment between asset life and the five yearly reset.

Recent developments have challenged this underlying assumption. Input costs have markedly increased, driven by global supply chain issues as well as the fact that most TNSPs in Australia are now competing to procure synchronous condensers from a limited number of global manufacturers.

This has been compounded by initial System Strength Unit Prices in several regions being much higher than expected. This has materially affected investor confidence that SSUPs will necessarily fall between SSUP pricing periods, and has increased the risk perception that future instability may drive SSUPs still higher.

These factors have contributed to a situation where investors increasingly view the 5 yearly reset as a material downside risk, driving higher risk premiums. This may in turn drive developers to elect to self remediate, where incurring these fixed, upfront costs is preferable to the uncertainty of a System Strength Charge that can vary significantly in future years.

Inability to revise System Strength Unit Prices downwards during the 5 yearly period

A related issue is that the System Strength Unit Prices themselves are fixed during the 5-year period and cannot be reduced downwards, even if material costs savings are identified in that period. This means that any cost reductions identified by the TNSP cannot be readily transferred to participants during the 5 yearly period. This has been identified as a problematic inflexibility by several TNSPs.

Powerlink has submitted the Resetting Powerlink's system strength unit prices rule change on 7 December 2023, to amend the NER to allow its SSPs to be revised within this 5 year period. Powerlink has noted that it expects that a revision should see its SSPs reduce, to be more in line with other regions. The CEC is supportive of this initiative and commends Powerlink for their work in recognising and addressing these issues.

While Powerlink's proposed rule change should help to address the specific issue that has arisen in Queensland, structural issues remain regarding the general inflexibility to readjust SSUPs during the five year system strength price control period.

It's acknowledged that the current situation may be ameliorated over time, as the market learns how the new frameworks will operate and is able to determine whether current input cost movements are structural or cyclical.

However, this learning is likely to come too late, given the significant quantities of new generation and storage investment that will occur in coming years, due to schemes like the Capacity Investment Scheme (CIS) and the various state based mechanisms.

We also acknowledge that better information and transparency frameworks may go some way to ameliorating these issues. For example, ex-ante guidance and greater clarity from the AER on the inputs and assumptions used in setting the SSUP, will allow investors to make more informed decisions on likely impacts of input cost changes and assumptions, and factor these into to their analysis of future prices.

Again however, this is unlikely to materially reduce the perception of downside risk in the near term, materially affecting the costs of investment to meet state based schemes and the CIS.

Flexibility is therefore required under the NER to allow SSUPs to be revised down, where System Strength Services can be delivered at lower prices than were originally published.

Resetting of System Strength Unit Prices - Addressing the Issue

Risk perception of increases in System Strength Unit Prices between each five year period

Recommendation: amend the approach taken to allowed changes in the SSUP between system strength charging periods. It's recommended that a 'side constraint cap' is the preferrable approach.

We consider that the preferable approach to address this issue would be to impose a 'downward side constraint' on the 5 yearly reset.

Side constraints refer to the concept of limiting the allowed degree of change in the System Strength Unit Price, from one pricing period to the next. We consider this side constraint should limit SSUP prices to moving downwards between periods.

This approach would provide a significant increase in investor certainty regarding the potential magnitude of future SSUP movements. It is also consistent with the underlying assumption that learning rates, scale efficiencies and technology cost reductions should drive cost reductions over time.

This approach would likely require material changes to the NER.

We understand the underlying rationale of the AEMC for the original model was to adopt pricing approaches that are as granular as possible, including over time, under the assumption this would contribute to more dynamically efficient outcomes on the power system.

We strongly encourage the AEMC to consider the counterpoint to this argument, namely that overly complex and unpredictable pricing outcomes that can change materially every 5 years, actually drives investment uncertainty and is likely to reduce dynamic efficiency.

Recommendation: Introduce flexibility for SSSPs to revise SSUPs downwards during a regulatory control period, where new information demonstrates that system strength obligations can be delivered at a lower cost than what was initially published.

As discussed above, we understand that several TNSPs have identified the inability to revise down their System Strength Unit Prices during the 5 year period as a key impediment to efficient pricing. This can be especially problematic where TNPS are required to publish prices based on general estimates of the long run cost of providing system strength, well in advance of being able to run RIT-T processes to identify the actual lowest cost solution.

This would be a relatively simple change that is likely to see immediate and positive outcomes on the power system.

We expect such an approach would include changes to the NER.

6. System Strength Remediation Location Flexibility

At the connection application phase, a connecting party has the option to either pay the system strength charge, or undertake self remediation of their System Strength Impact.

Self remediation can take various forms, such as installation of a synchronous condenser or grid forming battery by an individual proponent, behind the connection point.

However, other co-ordinated options might also be available for generators who elect to self remediate. In particular, it may be possible for multiple connecting generators to collectively meet their system strength obligations, by jointly funding or contracting with, an asset located in-front of their respective connection points.

This could include assets located in the shared transmission network, or an equivalent situation such as in a designated network asset (DNA). For example, several generators connected within a DNA may choose to jointly fund a syncon, or contract with a battery operator located within the DNA, to provide services to meet each of their self remediation needs.

We consider these kinds of solution could drive significant cost savings, by achieving scale and scope economies. They would provide an alternative to TNSP provided system strength solutions – or could even be contracted by the TNSP as a network support agreement – in turn placing downward pressure on the costs of providing system strength services.

The CEC is aware of this kind of solution having already been applied in the NEM, with the existing Synchronous condensers in Buronga NSW installed to support the Finely solar farm, which is located over 300 kms away. (This solution was allowed as it was implemented before the introduction of the SSIAG.)

Despite the potential benefits associated with these kinds of solutions, they are not allowed under existing processes. Section 5.1.2 of the SSIAG states that remediation works need to be located *behind the connection point* of a connecting generator.

Flexibility should therefore be available to connecting parties to select the most efficient solution.

System Strength Remediation Locations – Addressing the Issue

Recommendation: Remove the restriction that prevents location of self-remediation in front of the connection point

We understand that addressing this issue would be relatively easy and would involve AEMO making some minor changes to the SSIAG, through its standard guideline consultation process.

7. Withstand SCR Assessment

The system strength frameworks include an obligation on connecting generators to limit their demand for system strength. This obligation operates through the Generator Performance Standards (GPS), being the technical requirements all generators must meet in accordance with the generator access standards in NER clause S5.2.5.

This specific system strength demand side obligation is enabled through NER clause S5.2.5.15, which describes a Short Circuit Ratio (SCR) access standard. This access standard requires that a generator have the capability to operate stably down to a SCR of 3 at the connection point.

Demonstrating compliance with this is access standard is set out within the SSIAG in the form of withstand SCR tests, as described below.

Withstand SCR Assessment Test Requirements

The SSIAG requires that the withstand SCR of a connection is assessed as a minimum through dynamic simulation studies in a SMIB environment (per Section 7.4 of the SSIAG). The power system modelling tests to be undertaken are defined in Appendix B of the SSIAG and requires withstanding a change in SCR of 10 to the post fault Withstand SCR at the point of connection. Concerns have been raised that these tests are not actually passable (due to power transfer limitation rather than control system stability).

In brief, the issue with these requirements relate to how compliance is modelled. Several CEC members have identified that these tests applied by AEMO may not be passable, due to their overly onerous nature.

Withstand SCR Assessment – Addressing the Issue

Recommendation: AEMO, in consultation with industry, to reassess the specific tests applied to assess compliance with S5.2.5.15, to ensure their practicability, and to develop a methodology that sets out practical guidance as to how these tests should be conducted.

To ensure the Withstand SCR assessment tests are achievable, it is important to ensure that the tests required under Appendix B of the SSIAG focus on those matters relating to control system stability and that the tests can be passed. Providing examples demonstrating that these tests are actually passable by a generator would assist.

We understand that AEMO has already commenced work in developing a revised methodology to address these identified issues. The CEC welcomes this initiative, and will continue to work with AEMO wherever necessary to assist in development of this methodology.

8. Grid Forming Inverters

Grid forming inverter capability is rapidly evolving with an increasing number of OEMs providing this functionality. Grid forming inverters have the capability to provide similar services to synchronous generators – put simply, they can actively provide system strength, reducing the IBR generator's demand for system strength to zero, or even adding to the overall supply of system strength.

A key issue is that it is unclear as to whether grid forming inverters need to pay System Strength Charges and/or if they can provide System Strength Services.

There is some great work currently being undertaken by AEMO to provide OEMs guidance on the functionality required by a grid forming inverter via the AEMO voluntary specification.[10]

However, it is not clear whether an IBR that meets the Core or Additional capability requirements of AEMO's voluntary grid forming specification will automatically be considered to not be consuming system strength and/or providing system strength. The present practice is for projects to undertake extensive power system modelling as per the SSIAG and there are questions as to whether some of the tests can actually be passed.

Providing certainty that a grid forming inverter can provide System Strength Services if it meets either the Core or Additional capability requirements of AEMO's voluntary grid forming specification would provide certainty to projects.

The CEC also understands that NSPs are assessing the technical feasibility of grid forming BESS to provide System Strength Services such that NSPs can contract with them.

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[10] Australian Energy Market Operator, *Voluntary Specification for Grid-forming Inverters, Version 1.0, 19 May 2023*, 2023.

Grid Forming Inverters & System Strength – Addressing the Issue

Recommendation: AEMO should provide further guidance and clarification regarding the treatment of grid forming inverters under the system strength frameworks, particularly as this relates to a grid forming inverters relative consumption, or provision, of system strength services

Grid forming inverters are required to follow the same process as grid following inverters to demonstrate that they do not consume system strength, or to demonstrate that they provide system strength. This process requires onerous power system modelling, without certainty as to the outcome.

AEMO have undertaken extensive work to prepare a voluntary specification for grid forming inverters. However, clear and unequivocal acceptance that an IBR does not consume System Strength when meeting the Core capabilities in AEMO's grid forming voluntary specification would provide investment certainty and avoid extensive power system modelling which is the present practice.

Further clarity and certainty regarding the treatment of grid forming inverters should ultimately be provided in the NER, through either clauses 5.3.4A and B, or in the generator access standards set out in NER schedule 5.2.5.

However, recognising the complexity of this area, its acknowledged that this may be some years away. It is also likely that significant work will be needed to engage with OEMs to define grid forming capability, before this can be standardised in the NER.

9. Transitionary Arrangements

The demand side component of the System Strength rule came into effect on 15 March 2023. Projects would have been at different stages of the connection process whether that be the connection enquiry or the connection application stage.

Consequently, some members have identified that it isn't clear whether a project would follow the new rule or the old rule, depending on the stage that stage that the project is at.

This is likely to be less of an issue as time progresses.

Transitionary Arrangements – Addressing the Issue

Recommendation: AEMC to provide greater clarity on the transitionary arrangements for projects that were at the connection enquiry or connection application phase following commencement of the demand side rule.

This may take the form of a guidance note, or bespoke engagement with members who are affected by the transitional arrangements. The CEC is happy to facilitate these engagements as needed.

10. Revoking an Election to pay the System Strength Charge

The NER requires a connecting party to decide, at the time of submitting a connection application, as to whether it will pay the System Strength Charge or undertake self-remediation. Once this decision has been made, it cannot be revoked under NER clause 5.3.4B(b1).

As we understand it, there are two key use cases where this situation may impact generators.

Firstly, a generator may wish to revoke its decision to pay the system strength charge midway through its connection process – ie, once it has received its offer to connect but has not yet proceeded through the registration process and commissioning.

Secondly, a generator that has finalised its connection and is in its main operating life, may wish to pay the System Strength Charge for one pricing period, but reserve the right to switch to self-remediation solution at the end of that period. This may represent an efficient outcome if the SSUP determined in the next pricing control period increases to an inefficient level.

Allowing generators to revoke their initial decision to pay the system strength charge under both scenarios would help address the uncertainties associated with changes in the SSUP at the end of a pricing period, as well as providing a competitive constraint on the level at which SSUPs are set.

Generators who wish to pursue this option during the connection process must withdraw their connection application and resubmit it, which can result in significant delays to the schedule and additional costs. Generators who wish to do so during their main operating life will likely need to undertake extensive additional modelling.

In both cases, we understand the main regulatory pathway available to generators to achieve this outcome is to go through a NER clause 5.3.9 process. NER clause 5.3.9 requires a generator who is making changes to its plant to undertake additional modelling, to ensure it remains compliant with its generator performance standards.

The 5.3.9 provisions are currently being reassessed by AEMO through the Connections Reform Initiative.

Revoking an election in relation to paying the System Strength Charge – Addressing the Issue

Recommendation: That generators have the ability to revoke a decision to pay the System Strength Charge and elect to self remediate, both during the period of connection application as well as during the main operational life of the generating asset.

The inability to revoke an election to pay System Strength Charges following the submission of a Connection Application can result in additional costs and impacts to delivery schedule if a new Connection Application needs to be submitted.

Flexibility to re-assess a connection application rather than withdraw and resubmit would significantly reduce costs and schedule risks for projects, at least during the connection process.

Furthermore, parties should have the ability to change from paying the System Strength Charge self remediating, during the main operating life of the asset, if this proves to be a more efficient outcome. While its acknowledged that some further modelling may need to occur at that time, the costs and complexity of this should be addressed through changes to the 5.3.9 process.

We consider that both of these outcomes would require changes to the NER. We consider the most appropriate avenue for consideration of this should be through the next stages of the review of the 5.3.9 process, which is being addressed as part of the next stages of the ongoing Connection Reform Initiative.

11. Distribution Network Connections

The current focus of system strength frameworks has been on high voltage transmission networks. However, an increasing number of generators are connecting to the lower voltage distribution networks. The system strength frameworks do not currently effectively account for generators seeking to connect in this manner.

Connecting to distribution networks are challenge under the existing system strength framework due to the following:

- Distribution network service providers (DNSPs) cannot be System Strength Service Providers (SSSPs) under the NER. Only Transmission network service providers (TNSPs) can be SSSPs.
- System strength nodes can only be specified on the transmission network of the SSSP.[11]
- Projects connecting to distribution networks typically have large location factors due to their electrical distance to transmission level system strength nodes.
- System Strength issues on the distribution network typically occur at locations electrically distant from the closest transmission network.
- Although an SSSP can procure System Strength Services located on the distribution network, their effectiveness is assessed based on requirements defined at the system strength node on the transmission network. Hence a System Strength Service on the distribution network is unlikely to be an effective solution to address requirements at a transmission level node.
- Joint planning between TNSPs and DNSPs is a requirement under the NER (including for the provision of System Strength), however solutions at the transmission network have limited effectiveness on distribution networks due to the relatively large electrical distance.

There were two key reasons for excluding DNSPs from being SSSPs. Firstly, it was considered that having multiple SSSPs in a region could result in double up and inefficient outcomes. Secondly, and perhaps more practically, it was also considered the high impedances / resistances often encountered in lower voltage distribution networks would make the provision of centralised system strength services impractical.

The CEC considers this reasoning should be reassessed. While there may be some complexities associated with having multiple SSSPs in a region, this should be eminently manageable through good economic regulation and joint planning processes. Furthermore, many larger distribution networks – such as those of Essential Energy in NSW and Ergon Energy in QLD, are not that physically dissimilar to many transmission networks. We consider there could be material benefits in allowing networks like these to be SSSPs, particularly given the significant volumes of new generation seeking to connect into distribution networks in coming years.

Having said this, its recognised there are significant complexities associated with such a reform, many of which may not have been adequately considered here. Accordingly, an AEMC review of this issue would likely form the next appropriate step.

Addressing System Strength on distribution networks

Recommendation: that the AEMC undertake a review of the practicality of allowing certain DNSPs to become SSSPs and more generally, how system strength services might be more effectively provided to generators looking to connect onto the distribution network.

Projects connecting to distribution networks are by nature electrically distant from system strength nodes located on distribution networks, and hence are exposed to larger SSLFs. This acts as a key deterrent to efficient locational decisions.

Further work is required to ensure System Strength Services can be efficiently provided to generators connecting to distribution networks.

We recommend the AEMC undertake a review of the feasibility of allowing certain DNSPs to become SSSPs.

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[11] The CEC notes the decision made by the AEMC in the *Final Determination of the Efficient management of system strength on the power system rule change*, which partially accounted for some of the network providers who operated both distribution and transmission network infrastructure, by expanding the definition of 'applicable TNSP' to specifically account for AusGrid and TasNetworks. We also note that page 118 of the final determination acknowledges that SSSPs should make use of system strength provided by other networks, if this can be demonstrated to be efficient under the RIT-T. In theory, this might deliver system strength solution located within a distribution network, but only if it is originally picked up by the relevant SSSP, and only if it can be shown to pass the RIT-T . While we consider these amendments partially address the issues identified here, they nevertheless represent a stop gap solution, and are unlikely to address the underlying issue.

12. System strength requirements methodology – definitions of system strength

The regulatory concept of system strength is not easily aligned with actual physical characteristics of modern power systems. Various technical interpretations of the concept have been made over the years, including conflation of the concept of system strength with other characteristics, particularly power quality, static and dynamic voltage control as well as the provision of both synthetic and synchronous inertia.

Broadly speaking, the current regulatory definition of system strength accounts for the provision of fault current - the 'minimum level' of system strength – and management of IBR control interactions – the 'efficient level'.

The SSRM, SSIAG and the new network and system standards for stable voltage waveform, were collectively intended to address challenges associated with IBR controls – ie, the 'efficient' level.

However, some aspects of the SSRM are resulting in a conflation of this concept with other issues, such as power quality operational matters, in particular relating to voltage step changes. This is explored in more detail below, but in short it means that issues that are not really relevant to system strength are being captured in the frameworks, increasing costs for SSSPs and ultimately, connecting generators and consumers.

In more detail: SSRM and Voltage Step Changes

AEMO's System strength requirements methodology (SSRM) outlines the methodology for assessing:

- The minimum fault level (minimum level of System Strength); and
- Stable voltage waveform (efficient level of System Strength);

The minimum fault level methodology has a seven-step approach as follows per the SSRM:

- Step 1 – Consider existing requirements.
- Step 2 – Assess protection system operation needs.
- Step 3 – Assess voltage control system operation needs.
- Step 4 – Assess power system stability needs.
- Step 5 – Select critical planned outages.
- Step 6 – Determine minimum three phase fault levels.
- Step 7 – Adjust requirements for application in the operational context.

Step 3 "Assess voltage control system operation needs" requires per Section 4.3 of the SSRM:

"…to enable stable operation of voltage control systems, such as capacitor banks, reactors and dynamic voltage control equipment. AEMO will assess these needs in accordance with the applicable Australian Standard (AS/NZ 61000.3.7:2001) which provides voltage step change limits for switching of capacitor banks or reactors while remaining stable".

The SSRM does not specify the delta voltage (step change limit) but instead refers to AS/NZS 61000.3.7 which has limits on voltage fluctuations and flicker, in particular rapid voltage change. AS/NZS 61000.3.7 however refers to power quality phenomena and is not related to control system stability. Trying to resolve these power quality issues by procuring System Strength Solutions in the form of increasing fault levels is inefficient and will result in excessive levels of System Strength Services being procured.

Furthermore, the impact of voltage step changes due to switching shunt devices is most efficiently managed not by increasing fault levels (by procuring System Strength) but by alternative methods such as point on wave control or switching shunt devices in smaller steps.

The implication of this conflation is that the current system strength frameworks may be driving investments in or operation of network and generating equipment that may not actually be needed to meet the two key components of system strength – ie, the minimum fault level and management of converter interactions.

While these investments may very well be needed on the power system, they should be developed and paid for through the proper channels. Failure to do so will see additional and unnecessary costs loaded into the System Strength Charge for generators, exacerbating the already problematic pricing issues we have considered in this report.

A related issue is that of minimum fault level requirements calculated at different nodes.

Currently, SSSP's are required to plan system strength based on requirements in the national standard, which forecasts system strength needs in each NEM region over a 10 year period. That national standard is set by AEMO National Planning through its system strength report released in December each year.

AEMO National Planning follows its System Strength Requirements Methodology (SSRM) when setting the standard. Section 4.1 of the methodology requires AEMO to take the existing (i.e. historical) requirements as a starting point for setting minimum three fault level assessment.

This means that the minimum fault level requirement can be determined by existing synchronous coal generation, on the basis that power system is known to be secure under those conditions. This can occur in parts of the power system where large volumes of thermal coal generation was located.

However the rules only require AEMO to meet S5.1a.9, which requires sufficient minimum fault level to enable protection systems, voltage control systems and the overall power system to remain stable. This means that if minimum fault level requirements were reviewed based on *actual* system needs (rather than relying on historical placement of generation), they might be significantly lower.

For example, in Victoria pre-contingent minimum fault level requirements at the Latrobe Valley SSN are 7,700 MVA, driven by existing coal in the region. While AEMO is obviously the only party able to effectively assess and model requirements, we consider these volumes of minimum fault levels could potentially be lowered, by reviewing the actual protection requirements of major network assets, while accounting for expected thermal generation exits.

The consequence of this is that investment required to meet minimum fault level requirements may be inefficient for customers, and may not be targeted to locations with high renewable interest.

If the minimum fault level requirement at a particular node is higher than what actual generation patters and network topology would strictly necessitate, SSSP's may end up procuring system strength solutions that are not strictly required, rather than investing in areas where they might deliver maximum benefit.

In other words, a minimum fault level requirement that is not biased towards historical needs could support far more renewables as it would allow the SSSP to pursue a dispersed portfolio of system strength solutions across a given region.

System strength requirements methodology: definitions of system strength - Addressing the Issue

Recommendation: AEMO reassess the SSRM and SSIAG to

- **ensure that system strength requirements and system strength costs to be borne by generators are only those related to control system stability / control system interactions and not power quality or operational matters.**
- **ensure that volumes of fault level procured at nodes reflect actual and expected outcomes on the power system, rather than being based on a backwards looking view of power system needs.**

It is important that System Strength issues in relation to IBR controls are not conflated with power quality issues or operational matters that are best managed via alternative solutions.

Power quality impacts of switching passive shunt devices are most efficiently addressed by alternative method such as point on wave controls and not by procuring system strength / increasing fault levels.

Assessing NSP voltage control system operation needs and limiting voltage step change limits by procuring system strength will lead to increased levels of system strength procurement. This will in turn result in heightened System Strength Charges, worsening existing issues. The end result of this may be an increased incidence of generators electing to self remediate, increasing the share of system strength costs borne by customers.

We recommend that AEMO reassess the specific definitions of the SSRM, with a view to addressing these identified issues.

We also suggests there is value in reviewing whether existing minimum fault level requirements at declared system strength nodes with high levels of existing synchronous generation are appropriate. In particular, we encourage AEMO to reconsider its historic assessment of fault level requirements at specific nodes in the power system.

Our Work & Next Steps

The CEC has been actively working with its members to understand and work towards resolving the various system strength related issues including:

- Engaging with members to consolidate and document the various issues being faced.
- Identifying the priority areas to address.
- Engaging with TNSPs and DNSPs to obtain a broader perspective and understanding.
- Actively engaging with the relevant market bodies - AEMO, the AEMC and the AER.

The CEC also welcomes AEMO's System Strength FAQ which provides some practical explainers.[12]

We consider that our recommendations made throughout this report will form the basis of future engagement with the market bodies, to determine appropriate next steps. In some cases this may be the lodgement of rule change requests, however in many other instances we consider both the AEMC, AER and AEMO can progress many changes more promptly through their own guidelines changes, or even through simpler operational procedure changes.

The CEC also welcomes the opportunity to engage with all Commonwealth, State and Territory counterparts, to explain the issues we have identified and work through some of the potential solutions. Getting these frameworks fully operational will be key to delivering on the many jurisdictional renewables programs. The CEC stands ready to work collaboratively in order to achieve this.

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[12] Australian Energy Market Operator (AEMO), *System Strength Framework Frequently Asked Questions V1.0*, 9 August 2023. Available: https://aemo.com.au/-/media/files/electricity/nem/system-strength-framework-frequently-asked-questions.pdf?la=en.